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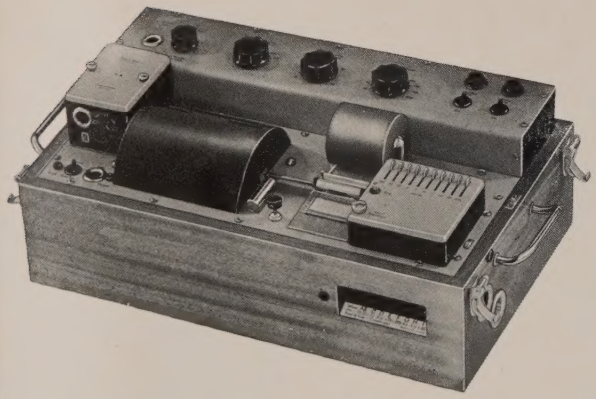
# INSTRUCTIONS AND APPLICATIONS

## Level Recorder Type 2304



A high-speed recording instrument designed for the measurement of reverberation time, noise level, and the frequency response of microphones and loudspeakers.

- Acoustic standing wave apparatus
- Artificial ears
- Artificial voices
- Audio frequency spectrometers
- Audio frequency voltmeters
- Automatic A. F. spectrum recorders
- Automatic frequency response recorders
- Beat frequency oscillators
- Condenser microphones
- Conductivity meters
- Deviation bridges
- Distortion measuring bridges
- Electronic counters
- Frequency analyzers
- Frequency measuring bridges
- Frequency response tracers
- G. M. tubes and accessories
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- Integration networks
- Level recorders
- Logarithmic potentiometers
- Megohmmeters
- Microphone amplifiers
- Microphone calibration apparatus
- Noise level potentiometers
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# LEVEL RECORDER

Type 2304

MAY 1958

# Contents.


**Description** ..... 3
General ..... 3
Technical ..... 4
**Operation** ..... 6
Gearbox ..... 7
Potentiometers ..... 8
Starting the Instrument ..... 9
Lower Limiting Frequency ..... 10
Writing Speed ..... 11
**Accessories** ..... 12
Recording Paper ..... 12
Scratcher Type 2360 ..... 14
Rotating Selector Type 4405 ..... 14
Inverter Type 4610 ..... 16
Automatic Reverberation Switch Type 4407 ..... 16
**Maintenance** ..... 18
**Applications** ..... 19
Checking Logarithmic Potentiometer ..... 19
Recording of V. U. from Broadcasting lines ..... 20
Recording of Frequency Characteristics ..... 21
Determination of Q-Value and Resonance Frequency of Tuned Circuits 21
Measurements of Temperatures and Temperature Differences ..... 22
Recording of the Frequency Response of Loudspeakers ..... 24
Recording of the Frequency Response of Microphones ..... 26
Recording of the Frequency Response of Hearing Aid Apparatus .... 27
Measurements on Air Filters ..... 28
Determining the Quality of Airborne Sound Insulation ..... 29
Comparison of Microphones ..... 31
The A. F. Response and Spectrum Recorder Type 3321 ..... 32
Automatic Recording of Harmonics ..... 32
Measurement of Reverberation Time ..... 33
Vibration Measurements ..... 36
Recording of Directional Characteristic of Loudspeakers ..... 37
**Specifications** ..... 39

# Description.

**General**

The Level Recorder is a high speed instrument for recording signal level variations within the frequency range 20 to 200,000 c/s.

It consists of an interchangeable input potentiometer, an a.c. amplifier, a diode peak rectifier circuit, a d.c. amplifier, and an electro-mechanical writing system.

Fig. 1 shows a block diagram of the instrument.

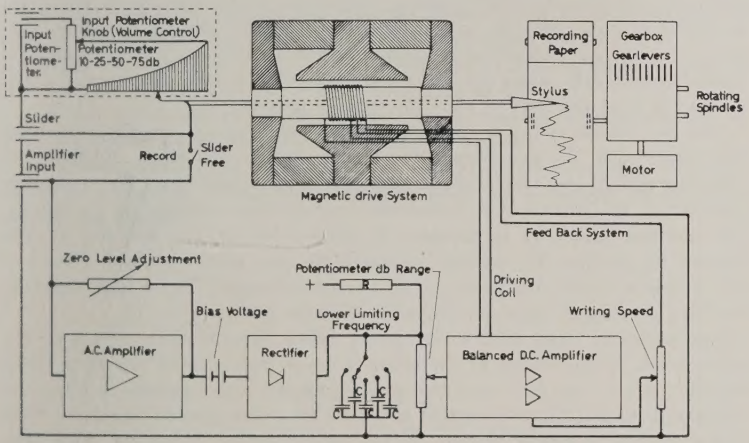



*Fig. 1. Block diagram of the Level Recorder Type 2304.*

The operation of the Level Recorder is based upon the servo principle. When the magnitude of the voltage applied to the input terminals is changed a current will flow through the driving coil of the writing system, thus moving the stylus, which is mechanically coupled to the input potentiometer. By the movement of the stylus the voltage delivered from the potentiometer to the a.c. amplifier will be altered until a stable condition is regained. In this way it is possible to obtain different ranges of voltage variations which can be recorded, by employing different input potentiometers.

A synchronous motor is used for the paper-drive, and by means of a gear box 10 different paper speeds are available.
Recordings are made either by a sapphire stylus on wax coated paper or by a pen for ink writing.
Different types of pre-printed recording paper are available.

**Technical**

The Level Recorder Type 2304 comprises an interchangeable input potentiometer to which the input voltage is led via the input jack and the volume control $P_3$ (see diagram inserted in the back cover). The potentiometer slider, which is mechanically coupled to the driving coil and the recording stylus, slides on the potentiometer's solid silver lamellae. From the potentiometer slider the a.c. voltages are led to an a.c. amplifier ($V_1$ and $V_2$). The gain is adjustable by changing the amount of negative feed-back by means of the potentiometer $P_1$. The a.c. voltage is rectified in the diode $V_5$. The time constants and thus the lower limiting frequency can be changed by switching in different capacitors by means of the switch 01 "Lower Limiting Frequency". The d.c. voltage is regulated by the switch 02 "Potentiometer db Range" which determines the resolving power of the Level Recorder, i. e. the change in level required to start the moving system.

The d.c. voltage is led to one tube $V_3$ of a balanced d.c. amplifier, whereas the other tube $V_4$ has connection to the switch 03 which controls the "Writing Speed", by changing the amount of feed-back from the secondary winding of the driving coil, connected between the cathodes of $V_7$ and $V_8$. The limiting diode $V_6$ is provided to secure the proper working of this control by limiting the control voltage at the d.c. amplifier input. The two d.c. amplifier tubes are balanced by the potentiometer $P_2$ so that changing of "Pot. db Range" does not influence the zero level.

The amplifier tubes control the power tubes $V_7$ and $V_8$ connected to the driving coil. If the voltage of the slider is lower than a fixed reference value, usually 10 mV, the d.c. amplifier gets a positive input voltage through the resistor R 46, and the coil current will flow in a direction so as to move the slider towards a higher voltage on the potentiometer. When the slider has reached a lamella with a voltage of 10 mV, the balance of the d.c. amplifier is established and the coil current will cease. A slider voltage higher than 10 mV will produce a negative control voltage sufficient to reverse the current in the coil and thus move the slider to a lamella with a voltage of 10 mV. The bias of the diode $V_5$, determined by R35 and R42, is 20 volts. When the a.c. voltage from $V_2$ is just a few tenths volts more than 20 volts the current in the coil will reverse. The turning point is thus very sharply defined. The stability of the bias is secured by the neon tube $V_9$. The level range of the instrument is thus exclusively determined by the potentiometer $P_4$.

Potentiometers are available with the logarithmic ranges: 10 — 25 — 50 and 75 db, and with linear range from 10 to 35 mV and 10 to 110 mV.

By means of the switch $N_1$, the amplifier input and the slider can be separated, making it possible to use the Recorder as a complete regulator for keeping constant sound pressures, voltages, currents, temperatures, tensions, velocities, accelerations, etc.

By inserting a chopper system "Inverter" Type 4610 recordings of d.c. voltages or a.c. voltages below 20 c/s can be made.

The damping of the driving coil and consequently the writing speed is variable by the switch 03 in 9 steps from 50 mm/sec. to 1,000 mm/sec. A considerable damping is still left at max. speed, so that the overshoot is small. By reducing the writing speed to 700 mm/sec. the overshoot is negligible. At still lower writing speeds there will be no overshoot at all. In order to draw marking lines on the paper, it is possible by the push button switch $N_4$ to bring the coil to maximum at full speed, because the damping simultaneously is put out of function.

The European model of the Recorder is provided with a line voltage selector 04 for the amplifier and the motor. The motor and the amplifier which are connected through the separate fuses $F_2$ and $F_1$ and switches $N_3$ and $N_2$ respectively. The motor is a synchronous motor for 50 c/s.

The American model is for 115 volts only, and it has therefore no voltage selector. The motor is a synchronous motor for 60 c/s.

Between motor and paper drive a gearbox is inserted making possible 10 different paper speeds between 0.003 and 100 mm/sec.

In order to connect to the Recorder a Beat Frequency Oscillator, Spectrometer or a rotating switch two rotating spindles are accessible on the right side of the Recorder.

# Operation.

The power cable is connected to the a.c. line terminals. The voltage selector is set to the proper main voltage and the motor and amplifier switches are switched on.

To insert the paper in the Level Recorder the paper frame is pulled carefully upwards, see fig. 2.

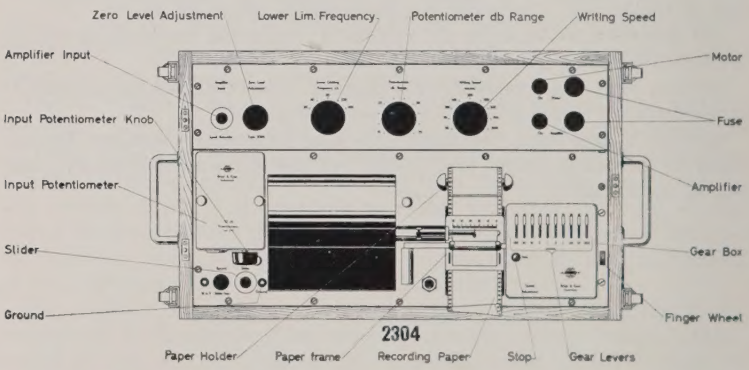



*Fig. 2. Drawing of the Level Recorder Type 2304 viewed from above.*

The recording paper is placed in the paper holder. Make sure that the spring-loaded steelballs fit accurately in the holder stands and that the laminated springs in the stands touch the edge of the roll with sufficient force to give the paper roll the necessary friction to stress the paper in use.

The paper is arranged so that the perforation corresponds to the "teeth" in the paper drive wheel. The paper frame is now pressed down on the paper until a small "click" is heard. It will then be locked by means of a snap lock arrangement.

To shift the paper all gear levers must be disengaged. This condition is obtained by pressing the button marked "Stop" in the gearbox, and the paper

can then be shifted by means of the small finger wheel to the right of the gear box. (Never shift the paper by pulling it directly!)

When the amplifier is on, the recording paper should always be in position. If not, the paper frame should under no circumstances be locked in operation position, because by scratching the base with the sapphire stylus this may be damaged. When having short intervals in measurements it is recommended to let the paper move with slow speed instead of stopping the paper drive, to avoid that the sapphire cuts through the paper and scratches the base underneath.

**Gearbox.**

The paper movement is started by pulling a suitable gear lever until it is locked with a "click" in advanced position. The paper speed is read in mm/sec. on the scale in the front of the gear lever. The following paper speeds can be obtained: 100 — 30 — 10 — 3 — 1 — 0.3 — 0.03 — 0.01 and 0.003 mm/sec. The last four speeds correspond to 36 — 10.8 — 3.6 and 1.08 cm/hour.

To stop the paper drive the knob "Stop" is pressed and the active gear lever will be released.

In order to change the paper speed the new lever is pulled in position, releasing automatically the lever previously engaged.

*Do not pull 2 gear levers simultaneously and get them both locked in active positions. The torsion is, particularly in low gears, so big that the wheels will break or the axles bend.*

The motor axle has a speed of 75 revolutions per minute. It is via a gear coupled to two rotating spindles accessible on the right side of the Recorder. The spindles rotate in opposite directions and the speed of rotation can be changed by changing the position of the wheel marked *W* on fig. 3. The following rotating speeds are possible 75 — 22.5 — 7.5 — 2.25 — 0.75 — 0.225 rv/min and 4.5 — 1.35 — 0.45 rv/hour.

To shift the position of the wheel the use of a screwdriver (or knife blade) may be necessary. With the aid of the screwdriver (or knife blade) the wheel

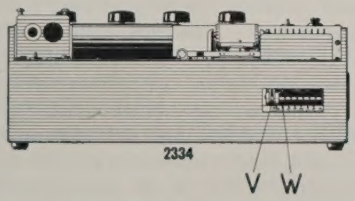



*Fig. 3. Drawing of the Level Recorder Type 2304 viewed from the front.*

is moved to its proper position. When the position is reached the wheel will be automatically locked onto the axle by means of a snap arrangement.

To make sure that the wheel is in its correct position the following rule of thumb may be used: W is in position A when it is moved so far to the left that it touches the hub of the wheel V, see fig. 3. To reach the position B, W should be moved a little to the right, and when the snap lock is engaged it sould not be possible to rotate W by "pushing" it with a finger.

Take care that switches and instruments connected to this axle do not become jammed, particularly at low speeds, causing either this or the gear wheel to be broken.

**Potentiometers.**

Prior to measuring, a potentiometer with suitable range and curve is selected. The logarithmic 50 db potentiometer, in rare cases the 75 db, is used for most acoustical and preliminary electrical measurements. The 25 db potentiometer is intended for use in accurate electrical measurements, and for the investigation of high-class amplifiers and transmission lines the 10 db potentiometer is used. The linear potentiometer is suitable in connection with measuring arrangements based on the carrier frequency principle. *The amplifier should be switched off when changing potentiometer.*

The various potentiometers have quite different level changes when moving from one tapping contact to another. Consequently, the Recorder's resolving power must be adjusted by the "Potentiometer db Range" to fit the range of the potentiometer. The calibration will give rough values only, as the limiting frequency and the recording speed also determine the maximum usable resolving power for a perfectly stable Recorder. When using a high "Lower Limiting Frequency" and low "Writing Speed", it is possible and often desirable to have a high resolving power, i. e. "Potentiometer db Range" on "10 db".

The linear potentiometer has in contrast to the logarithmic ones a varying level difference between adjacent tapping contacts. The steps will at one end correspond to those of a 10 db potentiometer, and at the other end the linear potentiometer will be similar to a logarithmic one with a range of 100 db. Consequently, when working with this potentiometer the "Potentiometer db Range" should be set to "10 db" and the "Writing Speed" reduced.

The input potentiometer has a resistance of 50 kohms. The resistance of the logarithmic and of the linear potentiometer is also about 50 kohms, thus producing an input resistance of the Level Recorder of 25 to 50 kohms, depending on the position of the input potentiometer slider.

The potentiometers have screened input terminal, built-in volume control and are provided with 108 solid silver lamellae. The normal writing width is 50 mm and the accuracy is 1 % of the writing width corresponding to the spacing between two lamellae. The frequency response characteristic is

flat up to 250 kc/s. 2 or 3 small condensers are placed on different points on the lamellae to correct the frequency characteristic.

The following Potentiometers are available:

| *Accuracy:* | | | |
|---|---|---|---|
| 2 % of full scale | Type 2343 | 10 to 35 mV | Linear Potentiometer |
| 2 % of full scale | - 2344 | 10 to 110 mV | Linear Potentiometer |
| ± 0.2 db | - 2345 | 10 db | Logarithmic Potentiometer |
| ± 0.3 db | - 2346 | 25 db | Logarithmic Potentiometer |
| ± 0.5 db | - 2347 | 50 db | Logarithmic Potentiometer (standard equipment) |
| ± 1 db | - 2348 | 75 db | Logarithmic Potentiometer |

The Level Recorder is delivered at catalogue-price with one potentiometer. When nothing else is specified, the Recorder is delivered with Potentiometer Type 2347, 50 db logarithmic.

**Starting the Instrument.**

When the amplifier is switched on, the tube lamp on the paper will light. When the tubes are hot, slight touch on the knob N4 will make the stylus give maximum deflection. During the adjustment of the apparatus before measurements, it is recommended to work with a comparatively low writing speed, for ex. 200 - 300 mm sec. in order to save the coil from too many and too heavy blows against the ends of the magnetic system.

When the Level Recorder is used for measurements of absolute voltages, i. e. with a fixed zero level on the logarithmic potentiometers of for instance 10 mV, the input jack J5 is connected to the jack "10 mV" J3 by means of a short cable. The volume control P3 in the input potentiometer is turned to maximum, the "Lower Limiting Frequency" to 20 c/s, the "Writing Speed" to 200 mm sec., the "Potentiometer db Range" to the value which is found suitable for the measurement, and finally the "Zero Level Adjustment" P1 is turned so much, that the stylus is standing exactly on the lowest of the 11 horizontal lines on the recording paper. After this adjustment all voltages are recorded in db over 10 mV. If recording is wanted over another reference voltage this must be connected from an external voltage source, and the adjustment be made as before. However, it is not possible to get a lower reference value than approximately 3 mV, and values lower than 10 mV should be avoided because the decrease of the negative feed-back will diminish the usable frequency range.

When a higher reference value than about 12 mV is wanted, the volume control P3 on the input potentiometer should also be turned. Reference values above 10 mV will then be obtained without any difficulties. Take care not to overload the input potentiometer. Maximum is 2 watts. In

recordings of reverberation times and in many cases also in recordings of frequency responses, a known reference value is without importance, and the volume control P3 is only adjusted so that the full level range to be recorded lies within the recording paper.

Usually P3 ought to be adjusted so that noise and hum level is a few db above the zero line of the paper, as it often might be valuable to obtain a clear impression of the noise level. At the same time one avoids the coil incessantly beating against the lower end of the magnetic system during the measurement.

*N.B.* Do not touch, press or bend the small aluminium bridge which makes the mechanical connection between coil and scratcher. The thin wires to the coil may break by mechanically overloading.

**Lower Limiting Frequency.**

In measurements in the audio frequency range the "Lower Limiting Frequency" is set to 40 or 20 c/s. Where low frequencies are of no measuring interest, it is recommended to set the limiting frequency to 80 or 200 c/s. whereby overshooting at high writing speed will be diminished. In measurements at high frequencies as in the carrier frequency range the limiting frequency should be chosen as high as possible. The calibration of the switch applies to the —3 db limiting frequency. See fig. 4.

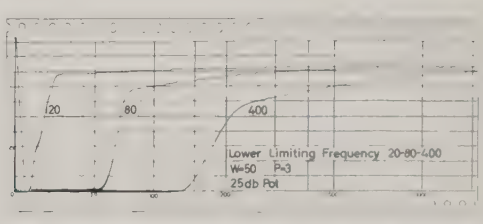



*Fig. 4. Frequency responses for 3 different settings of "Lower Limiting Frequency": 20, 80 and 400 c/s. Potentiometer: 25 db. Paper speed: 3 mm/sec Writing speed: 50 mm/sec.*

**Writing Speed.**

Maximum writing speed is very seldom required, and it is therefore recommended to work with some damping, thus saving the moving coil system, and at the same time overshooting is completely avoided. The knob "Writing Speed" is calibrated in terms of approximate recording speed in mm sec. The maximum speed is about 1.000 mm sec., corresponding to

1,500 db/sec. with a 75 db potentiometer. Fig. 5 shows the influence of various writing speeds.

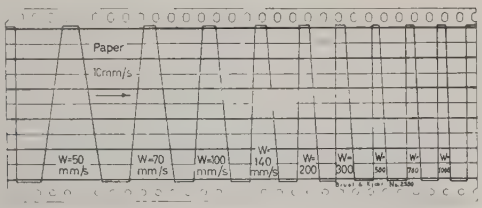



*Fig. 5. Recording with different settings of "Writing Speed": 50 — 70 — 100 — 140 — 200 — 300 — 500 — 700 and 1000 mm/sec. Potentiometer: 25 db. Paper speed: 10 mm/sec.*

# Accessories.

**Recording Paper.**

Different types of pre-printed recording paper to be used on the Level Recorder Type 2304 in conjunction with other instruments such as the Beat Frequency Oscillator Type 1014 or the Spectrometer Type 2109 are available.

The paper can be supplied in several qualities such as white paper for ink writing, white-waxed black paper for use with a sapphire stylus and red-waxed, transparent paper, also for use with the sapphire stylus.

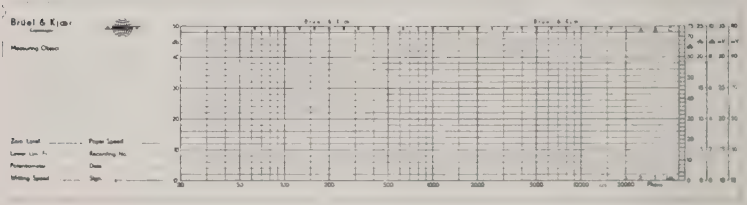



*Fig. 6. One of the three different types of recording paper for 3002 with pre-printed frequency diagram.*

Fig. 6 shows the frequency calibrated paper which should be applied when measurements are taken with the B.F.O. or the Spectromeetr in connection with the Level Recorder.

The red-waxed transparent paper is specially made for blue prints. However, the scales on the pre-printed paper are made in black, and will thus not be copied when blue prints or photostatic copies are made. Only the measured curve will then appear on the copy.

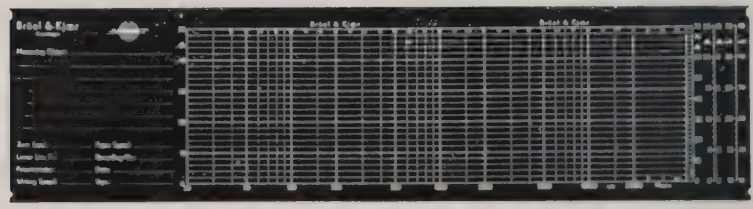



*Fig. 7. Photo of the Photographic Negativ Type QF 0002 with transparent frequency diagram.*

To obtain the calibrated scales together with the measured curve on the copy, it is necessary to use a Photographic Negative, Type QF 0002 and carry out a "double copying".

The Photographic Negative is a black film on which the scales appear as transparent lines, see QF 0002, fig. 7.

The following procedure can now be applied for the "double copying":

The recording paper strip is fastened to a board (or table) with scotch tape, such that the whole strip can be turned to one side and a piece of copying paper inserted underneath, without shifting the position of the strip. The Photographic Negative is then placed on the recorded paper strip, the printing on the strip coinciding precisely with the transparent lines on the film. By using scotch tape the film is fixed to the board. Care should be taken, that also the film can be turned to one side.

The photostat paper is now placed underneath the recording paper strip only and the curve illuminated. Then, without disturbing the photostat paper, the recorded paper strip is turned to the side, the black film in turn laid on the photostat paper, and the frequency diagram copied. By illuminating the curve somewhat longer than the black film with the frequency diagram, it is possible to enhance the former whereby it will stand out in contrast to the lines in the latter.

The following types of recording paper are available:

| *Type:* | |
|---|---|
| QP 2350 | White paper for ink writing, perforated, lined. Roll length 60 m. |
| QP 2351 | White waxed, black paper perforated, lined. Roll length 60 m. |
| QP 2352 | Red waxed, transparent paper, perforated, lined. Specially made for blue printing. Roll length 60 m. |
| QP 3609 | White waxed, black paper, without lines, perforated. Roll length 60 m. |
| QP 3610 | Red waxed, transparent paper, without lines, perforated. Specially made for blue printing. Roll length 60 m. |
| QP 3611 | Frequency calibrated, white paper for ink writing, perforated, to be used on Automatic Frequency Response Recorder Type 3302, Audio Frequency Spectrum Recorder Type 2311, combinations 1014 + 2304, 2109 + 2304 + UG 3004, 1014 + 2109 + 2304 + UG 3004, and A.F. Response and Spectrum Recorder Type 2321. Roll length 60 m. |
| QP 3612 | Frequency calibrated, white waxed, black paper perforated, similar to 3611. Roll length 60 m. |
| QP 3613 | Frequency calibrated, red waxed, transparent paper, perforated, similar to 3611. Specially made for blue printing. Roll length 60 m. |
| QF 0002 | Photographic Negative of frequency recording paper (Type 3613). |

**Scratcher Type 2360.**

When paper without pre-printed horizontal lines is used, the small Scratcher Type 2360 should be fixed on the paper frame. The scratcher is provided with 11 sapphires and draws 11 lines over 50 mm waxed paper. The scratcher is supplied to special order, but fits directly on any Level Recorder Type 2304.

**Rotating Selector Type 4405.**

The Rotating Selector Type 4405 comprises two pairs of contacts which can be closed by a rotating cam-disc, thus making it possible to make successive recordings at two different voltages.

Four different cam-discs are supplied to each switch. Three discs with one, two and three taps, and one for closing the contact approximately half the total time. The camdiscs can easily be removed by fingerscrews, after having removed the lid.

The Polar Diagram Recorder attachment is constructed for mounting on Level Recorder Type 2304 and Type 2334, the Automatic Frequency Response Recorder 3302 and the Audio Frequency Response and Spectrum Recorder 3321.

With the Polar Recorder it is possible to record polar diagrams showing, for example, the directional characteristics of microphones, loudspeakers, antennae, flourescent light fittings, ultrasonic generators, hearing aids, ordinary radio sets, etc.

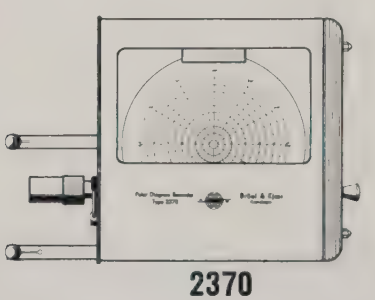
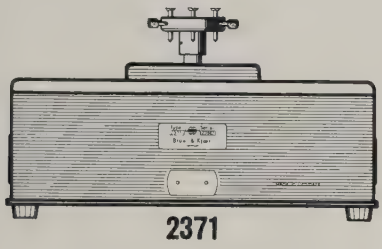



*Fig. 8. Polar Diagram Recorder Type 2370.*

The instrument mounted on the side of the Level Recorder consists of a rotating disc on which the recording paper is placed. The sapphire stylus arm in the Polar Diagram Apparatus is coupled mechanically to the moving system of the Recorder. The disc with recording paper is driven either from

the motor of the Level Recorder itself or from an external motor, as the coupling between the Level Recorder's motor and the Polar Diagram Recorder can be interrupted. Fig. 8 shows a drawing of the Recorder.

An auxiliary equipment to the Polar Diagram Recorder, a Turntable, has been constructed, fig. 9, on which the measuring object, for example microphone, loudspeaker, radioreceiver, fluorescent light mounting, hearing aid and so on, can be placed and rotated synchronously with the paper on the Recorder. The Recorder and Turntable are coupled together mechanically by a flexible shaft.



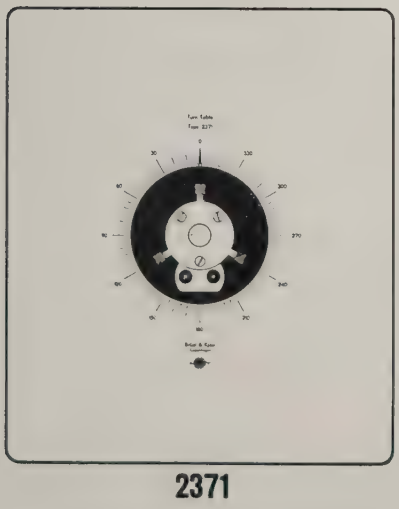




*Fig. 9. Turntable Type 2371.*

**Inverter Type 4610.**

The Inverter Type 4610 is designed as an accessory to the High Speed Level Recorder 2304 for the recording of d.c. and slow a.c. signals.

The essential component of this instrument is an a.c./d.c. chopper which is excited by a built-in 400 c/s oscillator. A very low noise level is obtained by means of a carefully screening of the chopper and the oscillator.

The d.c. signal to be recorded is led to the usual input terminal of the Recorder potentiometer. The connection between the potentiometer slider and the amplifier of the Recorder is cut off by means of a switch on the Recorder, and the chopper is inserted in this lead. In this way the d.c. signal from the amplifier and servo system of the Recorder will work in the usual way.

*Fig. 10. Inverter Type 4610.*

The recording of slow a.c. signals is possible when the signal is given a d.c. bias, so that the negative peak value of the signal is higher than the zero level of the Recorder.

This bias is supplied from a built-in stabilized rectifier and can be varied in steps of 10 db from 10 mV to 1 V. It can also be used as a reference voltage for controlling the proper setting of the gain control.

**Automatic Reverberation Switch Type 4407.**

The Automatic Reverberation Switch Type 4407 is designed as an accessory to the High Speed Level Recorder Type 2304, and is specially suitable for the automatic recording of reverberation curves.

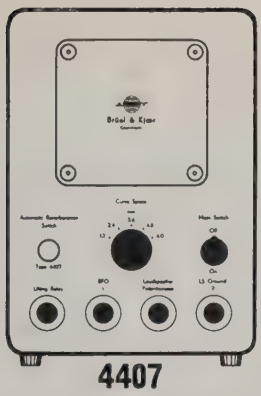



*Fig. 11. Automatic Reverberation Switch Type 4407.*

The Reverberation Switch is mechanically coupled to the paper drive of the Level Recorder and serves the following purposes:

1. It connects the loudspeaker to the B.F.O. in such a way that an impulse of short duration is transmitted in the room.

2. It short-circuits the loudspeaker during the period of time in which no impulse is wanted.

3. It controls the writing stylus on the Level Recorder by means of a specially designed lifting magnet, whereby only the reverberation process is registered on the recording paper.

4. It introduces a slight shift in the synchronization of the paper before each registration. The reverberation curves for different frequencies are thereby recorded on the paper with a constant spacing between the curves.

For further details see the "Instruction and Application" book for Type 4407.

# Maintenance.

Wheels and axles, in particular the fast moving ones, ought regularly to be lubricated with a high-quality thin engine oil. The gear-wheels are accessible when the cover over the gear-box is removed.

The synchronous motor has self lubricating bearings.

It is essential that the steel wires, on which the driving coil slides, are never oiled, even little quantities of oil or grease will change the friction and thereby the proper working of the system.

The potentiometer contact strip must be kept clean, care should be taken that metal dust does not short circuit the contacts. After cleaning, the contact strip should be lightly greased. The potentiometer is controlled by the measuring set-up shown in "Applications", page 19.

Under certain conditions it may be necessary to readjust the balance of the d.c. amplifier for inst. after replacement of any of the tubes $V_3$ and $V_4$. The balance is adjusted by means of the potentiometer $P_2$ (see the circuit).

The procedure is as follows: The switch arm (01) connected between $R_{46}$ and $R_{31}$ is connected to chassis (ground potential).

In case of balance, there should be no voltage across the moving coil, if any, adjust the potentiometer $P_2$ until the voltage reads zero. $P_2$ is accessible when the back grill is removed. It is placed at the panel behind $V_6$. When the voltage across the coil is zero, one can move the slider up and down the scale, and the slider will stop the movement at any setting, as soon as it is released.

If it is not possible to balance the amplifier with the potentiometer, the tubes $V_3$ and $V_4$ probably differ in characteristic.

First $V_3$ and $V_4$ are interchanged and the balancing procedure is repeated. If still no success the tubes must be replaced by new preferably aged ones

# Applications.

The field of applications of the Level Recorder 2304 is so extensive that it is only possible here to choose a few illustrating examples. There is a wide variety of applications in the acoustical and electro-acoustical field as well as for any phenomenon which can be converted into voltage variations. The Level Recorder has proved most useful for the recording of reverberation decay curves, noise levels, electrical voltage levels, and particularly the frequency response curves of microphones, loudspeakers, filters, amplifiers, hearing aids, etc.

**Checking Logarithmic Potentiometers.**

The logarithmic potentiometers for use on the Level Recorder Type 2304 can be checked in a set-up as shown in fig. 12.

The Level Recorder is mechanically coupled to the Beat Frequency Oscillator, Type 1014 (or the combination B. F. O. + Level Recorder Type 3302 may be employed), and the potentiometer to be tested is mounted on the Level Recorder.

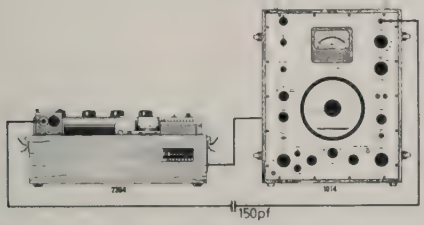



*Fig. 12. Measuring set-up for checking logarithmic potentiometer.*

A screened cable connects the output of the Oscillator to the input of the Level Recorder via a series capacitor.

When the frequency of the Oscillator is varied the impedance of the capacitor will also vary. As both the frequency scale and the potentiometer curve are logarithmic the recording obtained will be a straight line.

Fig. 13 shows a check on a 50 db potentiometer.

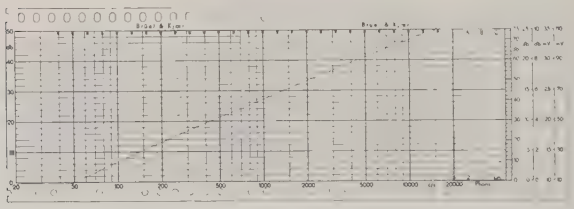


*Fig. 13. Recording obtained with a 50 db potentiometer.*

**Recordings of VU from Broadcastinglines.**

Fig. 14 shows some records of music levels. The left side of the top curve is made at a paper speed of 10 mm sec. and the right side at 3 mm/sec. A 75 db potentiometer is used. In recordings of VU from broadcasting lines, it is possible to record both noise level, maximum level and possibly overloading. Automatically will then on the same slip of paper be indicated the change in program as well as the quality of different microphone lines. By reducing the writing speed to 140—200 db sec. the level recorder is close in accordance with the standardized requirements of the VU meter, with regard to both correct dynamic characteristics and frequency response characteristics.

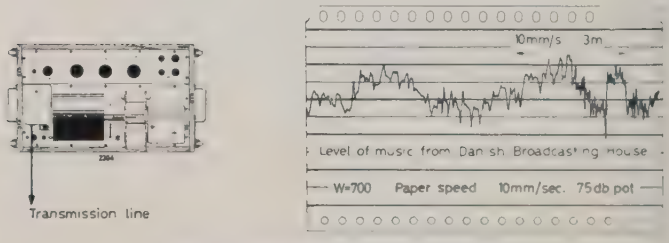



*Fig. 14. Recording of music level.*

**Recording of Frequency Characteristic**

of filters, transformers, transmission lines etc. The following apparatus are necessary: Level Recorder Type 2304, Beat Frequency Oscillator Type 1014 or 1015 with flexible shaft coupling to the recorder.

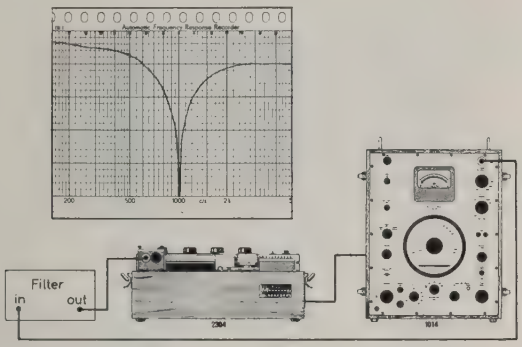



*Fig. 15. Measurement of freqency response of four-terminal A.F. network.*

**Determination of the Q-Value and Resonance Frequency of Tuned Circuits.**

The resonance frequency of a tuned circuit can be found by means of its resonance curve. For audio frequency circuits this curve may be recorded with the aid of the Level Recorder Type 2304.

However, if a Two Channel Selector Type 4405 is employed it is possible, at the same time to determine the Q-Value of the circuit. The method is somewhat approximate, but will in most practical cases be sufficiently accurate.

If the resonance circuit to be tested is a parallel network the current in the circuit should be kept constant during the measurement. A resistor is therefore connected in series with the network, and the voltage drop across it fed to the "Compressor input" of the B. F. O.

With the aid of the Selector Type 4405 both the voltages across the tuned circuit, and the voltage across the capacitor only, is recorded. Because of the relatively low input impedance (25– 50 kohms) the Level Recorder introduces an extra loss in the circuit to be tested. To eliminate this loss a Microphone Amplifier Type 2602 (or 2601) should be interposed between the measuring circuit and the input terminals of the Level Recorder. When a logarithmic potentiometer is used for the recording the distance between the two obtained curves, at resonance, gives the Q-value of the circuit in

decibels. A distance of $\alpha$ db between the curves is then equivalent to a Q-value:

$$20 \times \log Q = \alpha$$

To determine the Q-value of a series resonance circuit the voltage across the circuit is to be kept constant.

By means of a small series resistor the current in the circuit is measured and fed onto the input of the Level Recorder. The Two Channel Selector is now connected in such a way that the current is measured with and without the coil L in series with the capactior C.

Again the distance between the two curves at resonance indicates the Q-value of the circuit in decibels. For both types of measurements the capacitor is assumed to have negligible dielectric losses.

A measuring arrangement together with some typical recordings obtained from measurements on resonance circuits are shown in fig. 16.

TI 2430 is a symmetrical input transformer.

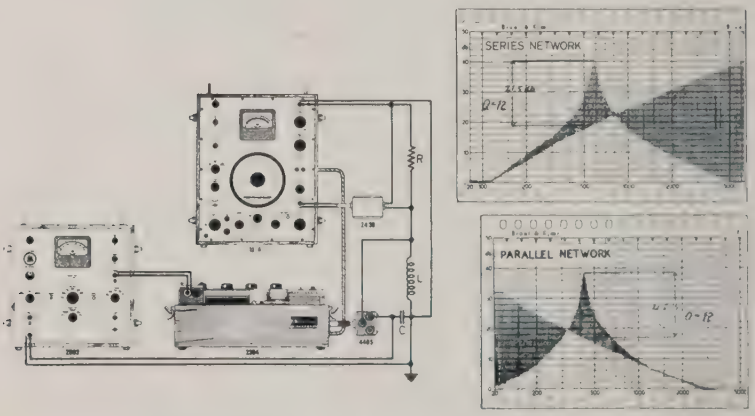



*Fig. 16. Determination of the Q-value and resonance frequency of tuned circuits.*

**Measurements of Temperatures and Temperature Differences.**

For electrical measurements of temperatures thermistors may be used. A measuring arrangement shown in fig. 18a employs two N. T. C. Negative Temperature Coefficient)-resistors, which enables the temperature on both sides of a concrete wall to be measured.

By means of the Automatic Frequency Response Recorder Type 3302, which is a combination of the Beat Frequency Oscillator Type 1014 and the Level Recorder Type 2304, a continuous recording of the temperature can be obtained. A sketch of Type 3302 is shown in fig. 17.

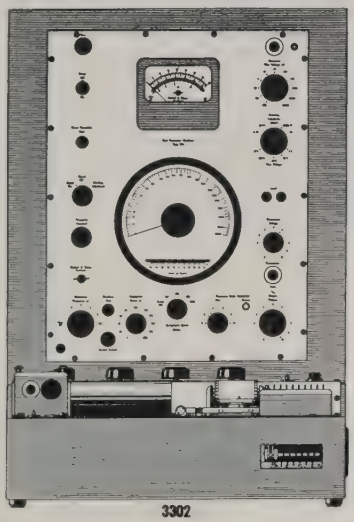



*Fig. 17. Sketch of the Automatic Frequency Response Recorder Type 3302.*

In order to record the temperature on both sides of the wall simultaneously, the Two Channel Selector Type 4405 is employed. This Selector is designed for direct mechanical connection to the Level Recorder and is automatically operated from the Level Recorder's motor.

By proper use of the B. F. O. compressor circuit a constant supply voltage is obtained; the current is determined by measuring the voltage drop across a fixed resistor, connected in series with the thermistor. See fig. 18a. This voltage is fed to the input terminals of the Two Channel Selector which automatically connects one or the other of the input terminals to the measuring amplifier in the Level Recorder.

Fig. 18b shows a recording obtained with the measuring arrangement shown in fig. 18a.

The wall is heated on one side with the aid of a constant heat source. Removing the source, the temperature drops gradually on this side of the wall, still rising on the other side due to the "inertia" of heat flow through the wall.

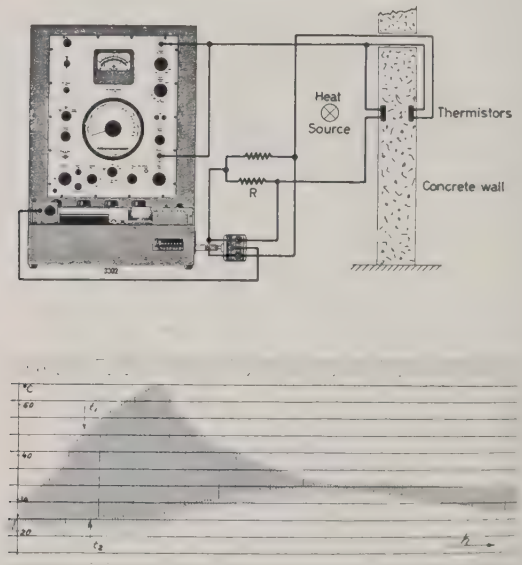



*Fig. 18. Measurement of temperatures on both sides of a concrete wall.*
*a) Measuring arrangement.*
*b) Simultaneous recording of the temperature on both sides of the wall.*

**Recording of the Frequency Response of Loudspeakers.**

Loudspeaker tests may be carried out either in an anechoic room or in the open air. To avoid disturbance from the noise, which is almost always present in the open air, a completely absorbing room should preferably be used for accurate measurements.

The loudspeaker to be tested may be fed either with a constant voltage or with a constant current. The latter condition will be equal to a constant mechanical force applied to the diaphragm of the loudspeaker.

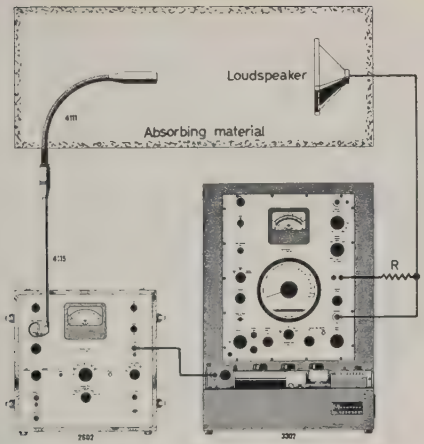



*Fig. 19a. Measuring arrangement used for recording the frequency characteristic of a loudspeaker.*

In fig. 19a a set-up for recording the frequency characteristic of a loudspeaker is shown. The loudspeaker is fed from the Beat Frequency Oscillator in the Automatic Frequency Response Recorder Type 3302 via a series resistor, the voltage drop across which is fed to the "Compressor Input" of the B. F. O. A constant current will be obtained in the circuit when the voltage across the resistor is approx. 1 volt.

The output voltage from the Condenser Microphone Type 4111 is fed to the Level Recorder in the Automatic Frequency Response Recorder via an Amplifier. This amplifier might be a Microphone Amplifier Type 2602 (or 2601) or a Frequency Analyzer Type 2105 (or 2109). The amplifier should be switched to have a linear frequency characteristic. An advantage gained

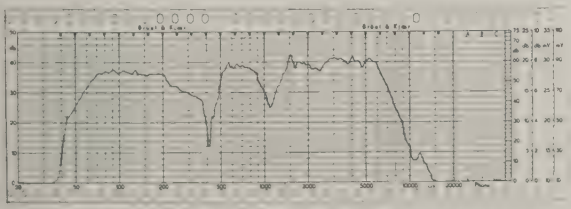


*Fig. 19b. Recording of the frequency characteristic of a loudspeaker mounted in a cabinet. The measurement was not carried out in a completely anechoic room, and the effect of reflections can be seen from the recording.*

by employing a Frequency Analyzer as an amplifier is that distortion measurements can be carried out with the same measuring set-up.

An example of a recording obtained with the above described set-up is shown in fig. 19b.

**Recording of the Frequency Response of Microphones.**

A typical measuring arrangement for recording automatically the frequency response of a microphone is shown in fig. 20a.

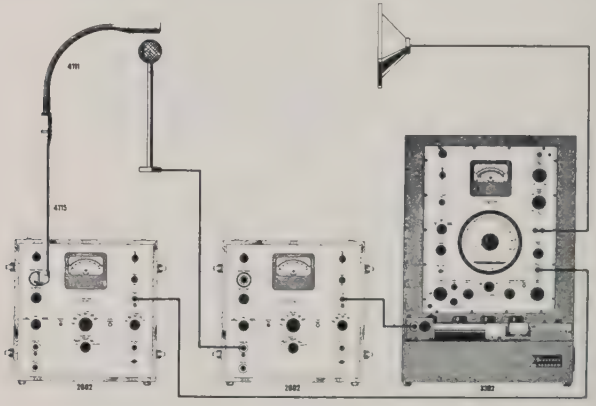


*Fig. 20a. Measuring set-up for automatic recording of the frequency response of microphones.*

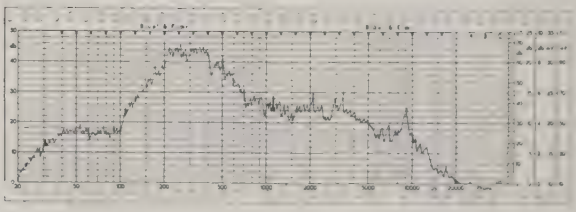


*Fig. 20b. Recording obtained with the set-up shown in fig. 20a.*

The microphone to be tested is connected to the Level Recorder Type 2304 via a Microphone Amplifier Type 2602. The sound source is a loudspeaker which is fed from the B. F. O. Type 1014, and the sound pressure in front

of the microphone under test is kept constant by proper use of the B. F. O. compressor circuit.

A standard Condenser Microphone Type 4111 is placed close to the microphone to be tested, and the output voltage from the Condenser Microphone is fed to the "Compressor Input" of the B. F. O. via a second Microphone Amplifier, thus enabling the sound pressure to be kept constant to within narrow limits.

Fig. 20b shows a recording of the frequency response of a microphone, employing a measuring set-up as described above.

**Recording the Frequency Characteristic of Hearing Aid Apparatus.**

With the measuring arrangement shown in fig. 21a it is possible to record automatically the frequency characteristic of hearing aids with acoustic input and acoustic output.

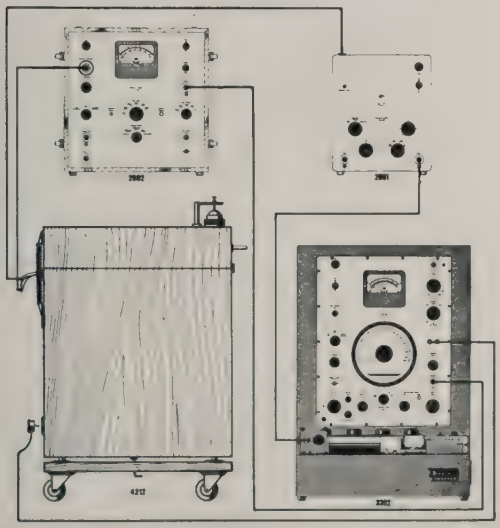


*Fig. 21a. Measuring arrangement for automatic recording of frequency characteristics. Consisting of: The Hearing Aid Test Box Type 4212, the Automatic Frequency Response Recorder Type 3302, the Microphone Amplifiers Type 2601 and Type 2602.*

The measured result can be obtained in the form of a complete frequency-amplitude diagram recorded on pre-printed, calibrated recording paper. See fig. 21b.

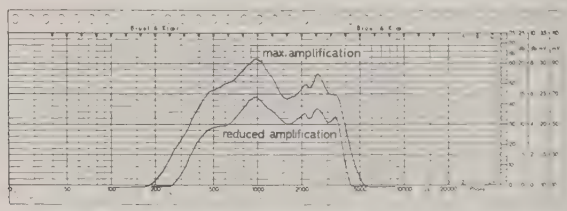



*Fig. 21b. Typical frequency characteristic of a hearing aid device recorded automatically with the arrangement shown in fig. 21a. Recordings were taken with two different settings of the hearing aid volume control.*

When small microphones are tested instead of hearing aids the artificial ear is not used, and the output from the microphone under test is fed directly onto the Microphone Amplifier Type 2601.

Furthermore by substituting the Microphone Amplifier 2601 with Frequency Analyzer Type 2105 not only the frequency characteristic of the hearing aid or microphone, but the harmonic distortion can also be measured.

If it is desired to record the frequency characteristic of the hearing aid with acoustic input and electric output, the measurement is similar to the measurement of microphones. However, in this case the output from the hearing aid amplifier may be fed directly onto the level recorder in Type 3302.

In cases where tests are to be made on hearing aids or earphones using electric input and acoustic output only the artificial ear of Type 4212 is used in connection with Type 3302 and 2601 or 2602.

**Measurements on Air Filters.**

Where high sound pressure levels are required the Constant Sound Pressure Source Type 4211 should be used as sound source. A set-up for measurements on the air filter of an automobile is shown in fig. 22.

The fact that good regulation is obtained by means of the compressor circuit, even when maximum output power is required from the Oscillator makes the B. F. O. Type 1014 excellently suited to this application.

In the measuring arrangement of fig. 22a the Automatic Frequency Response Recorder Type 3302 is employed, and the curves shown in fig. 22 b

give an indication of the attenuation of sound waves in the air filter. Curve a) is measured with open Source 4211 and curve b) with the filter mounted on the opening of the Source, the sound pressure level in both cases being 110 db, with reference to $2 \times 10^{-4}$ $\mu$bar.

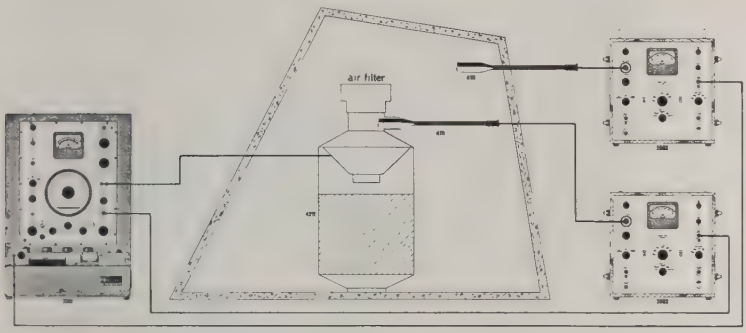



*Fig. 22a. Arrangement for determining the sound attenuation in an air filter.*

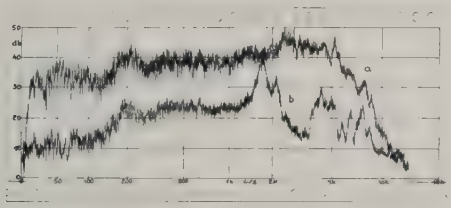



*Fig. 22b. Determination of the air filter's sound attenuation: Curve a) measurements without air filter, curve b) measurements with air filter mounted on top of the Constant Sound Pressure Source 4211.*

**Determining the Quality of Airborne Sound Insulation.**

The wall separates two room, one of which is used as "transmitter room", and the other as "receiver room".

With a measuring arrangement as shown only one Microphone Amplifier Type 2602 is needed, and the measured results are automatically recorded by the Level Recorder in the Automatic Frequency Response Recorder Type 3302.

The use of only one Amplifier 2602 is made possible by employing the Two Channel Microphone Selector, Type 4408, which is remotely controlled

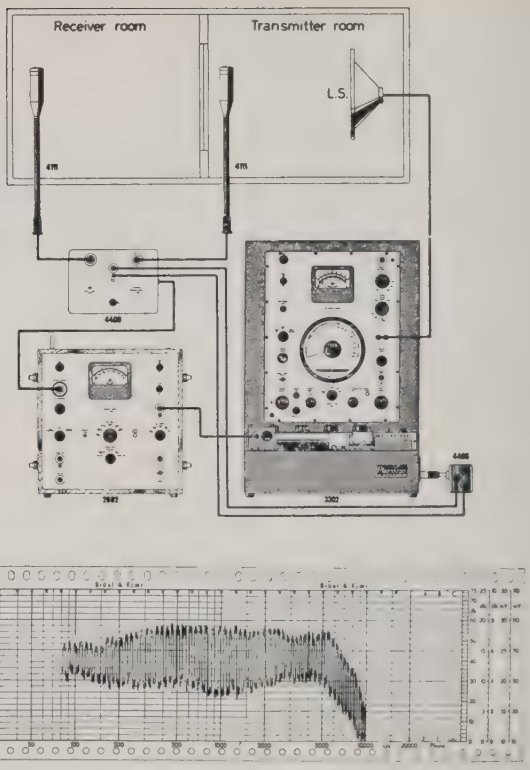



*Fig. 23. a) Measuring arrangement for automatic reading of the sound insulation properties of a wall. b) Recording obtained with a measuring set-up as shown in a). A 50 db potentiometer is used on the Level Recorder.*

by a Selector Type 4405. The input to the Microphone Amplifier is thus connected alternatively to the Condenser Microphone Type 4111, placed in the "transmitter room" and the one placed in the "receiver room".

Because of the mechanical coupling between the B. F. O., the Level Recorder, and the Selector 4405, both the sound level in the "transmitter room" and in the "receiver room" are recorded when the B. F. O. traverses the frequency range from 20 to 20,000 c/s. See fig 23.

For further details see Instruction manual for "Beat Frequency Oscillator" 1014.

**Comparison of Microphones.**

Fig. 24a shows a measuring arrangement for comparing the frequency characteristic of two microphones when measured under pressure condition.

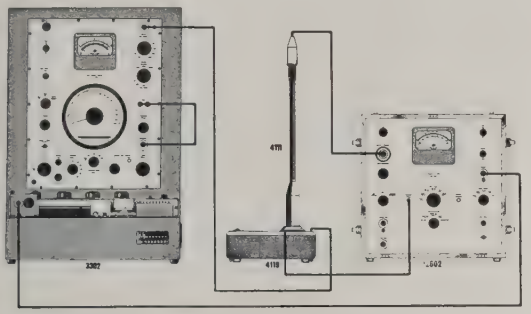


*Fig. 24a. Measuring set-up for the comparison of Condenser Microphones Type 4111.*

To obtain the said condition the Microphone Calibration Apparatus Type 4119 is employed. This is an apparatus specially designed for precision calibration of standard microphones, and full details are given in the manual for 4119.

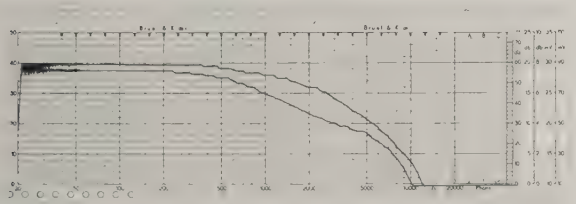


*Fig. 24b. Recording obtained with the measuring arrangement shown in fig. 24a.*

Fig. 24b shows a recording of measurements carried out as described. A 25 db potentiometer was used, and as may be seen one of the microphone cartridges tested has a poor frequency characteristic. This is due to a faulty diaphragm.

**The A.F. Response and Spectrum Recorder Type 3321.**

The application of the combination B. F. O. + Level Recorder has been illustrated in the first part of this booklet. Some important applications of the combination B. F. O. + Spectrometer + Level Recorder (The A. F. Response and Spectrum Recorder) will now be given, followed by two examples of the use of only Spectrometer + Level Recorder. Further applications of the combinations are referred to in the manual for Type 2109 and 1014.

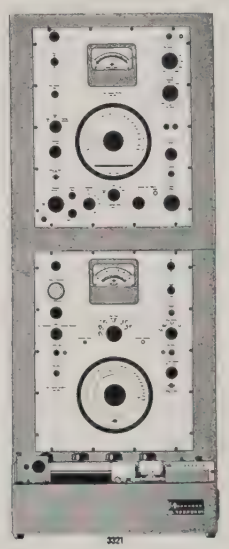


*Fig. 25. Sketch of the A.F.-Response and Spectrum Recorder Type 3321*

**Automatic Recording of Harmonics.**

The A. F. Response and Spectrum Recorder Type 3321 is excellently suited for automatic recording of harmonics. Fig. 26 a shows a measuring arrangement for investigating harmonic distortion produced in hearing aids. Usually the distortion produced in the electronic part of such a device (the hearing aid amplifier) is small as compared to the distortion caused by the electro acoustical transducing elements.

The measuring arrangement shown includes for this reason the electro acoustical system of the hearing aid, and fig. 26 shows a recording of the harmonics reaching the human ear when a pure tone of constant sound pressure is produced in front of the hearing aid microphone.

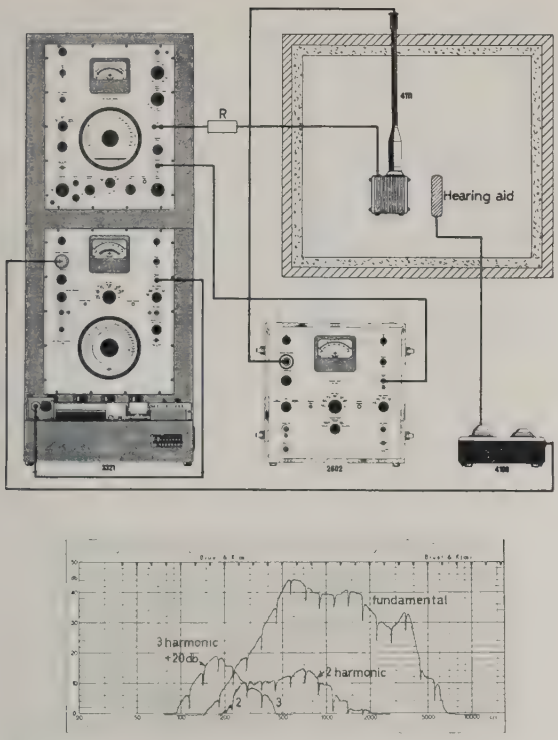



*Fig. 26. a) Measuring arrangement for measurement of harmonic distortion in hearing aids. b) Recording of the first, second, third and fourth harmonics measured in a set-up as shown in a).*

**Measurement of Reverberation Time.**

One of the most important factors determining the acoustic properties of a room is its reverberation time. This time may be measured in different ways, one of which is shown in fig. 27a, employing the A. F. Response and Spectrum Recorder Type 3321.

The B. F. O. of 3321 should be frequency modulated, and the on-off switching of the sound source is controlled from the Reverberation Switch Type 4407.

The bandwidth and modulation frequency of the warble tone is discussed in "Operation" of the B. F. O Type 1014, and by following these instructions

a reverberation curve will in most cases be obtained with only small fluctuations, the curve approximating to a straight line.

A well defined reverberation time can be found in this way for each frequency at which measurements are taken.

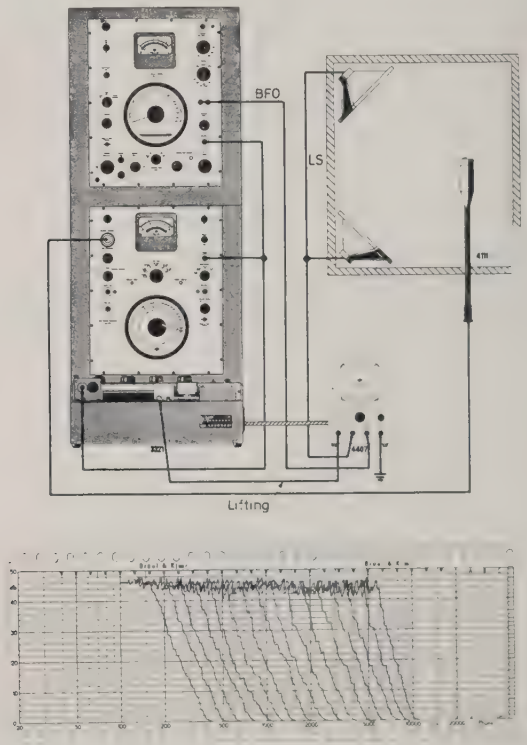



*Fig. 27. a) Method for automatic measurement of reverberation times. b) Recording obtained with a set-up as shown in a).*

The use of the Automatic Reverberation Switch enables an automatic recording of reverberation curves at different, pre-selected frequencies. Further information is to be found in the manual on Type 4407.

The Spectrometer is to be synchronized with the B.F.O., and care must be taken not to overload the apparatus at any time during the measurement.

If the switch on the front panel of Type 4407 is set to position "4.8", the wheel marked D used for the speed of the frequency sweep of the B. F. O. and Spectrometer, and the paper speed chosen to be 30 mm/s reverberation curves with a distance of ⅓ octave will be recorded. In this case it is possible to employ frequency calibrated paper for the recording. The synchronization of 4407 with the A. F. Response and Spectrum Recorder must then be carried out carefully. A method of synchronization which has proved to be very useful in the following:

The recording paper is synchronized with the scale pointer of the B. F. O. as described in "Instruction and Application" for 1014 and 2109. Then the automatic switch of Type 4407 is positioned such that in the moment the Level Recorder motor is started, the sound source is cut off. The position of this switch is very critical as the paper and the B. F. O. scale pointer moves with different speeds, and if the cut-off of the sound source does not follow immediately when the motor is started the synchronization between the paper and the Oscillator is "lost".

Fig. 27 b shows a recording obtained with the described measuring set-up.

When reverberation measurements are to be carried out at only a few frequencies, the Automatic Reverberation Switch Type 4407 need not be used. The sound source can then be switched off by means of the press-button marked "Oscillator Stop", or with the aid of a remote control device as described under "Operation" (of the B. F. O. Type 1014).

Fig. 28b illustrates the use of the Protractor Type 2361, which has been designed in order to facilitate the determination of reverberation time from recorded decay curves, the reverberation time being defined as that time it takes the sound energy to decrease 60 db. The protractor is divided in 4 sections, marked 75 db 10 mm/sec., 75 db 30 mm/sec., 50 db 10 mm/sec. and 50 db 30 mm/sec. Only when used in one of these 4 combinations will it give the reverberation time directly in seconds.

The protractor is, as shown in the figure, used by placing the thick line, which indicates the *left* section line (the line closest to the B in Brüel & Kjær), over the recorded decay curves in such a manner that one of the horizontal lines on the recording paper passes through the centre of the protractor. The reverberation time in seconds can then directly be read at the point where this horizontal line crosses the scale.

The decay curves should preferably be straight lines making it easier, even though the unavoidable fluctuations, to determine the average slope.

Have other paper speeds than 10 and 30 mm sec. been used, the determined reverberation times should be multiplied or divided by factors of 10.

*Examples.*

Paper speed 100 mm sec.: Use the sections 10 mm sec. and divide the reverberation times by 10.

Paper speed 1 mm sec.: Use the sections 10 mm sec. and multiply by 10.

If a 25 db potentiometer has been applied for the recording a section marked 50 db should be used and the determined reverberation times be divided by 2.

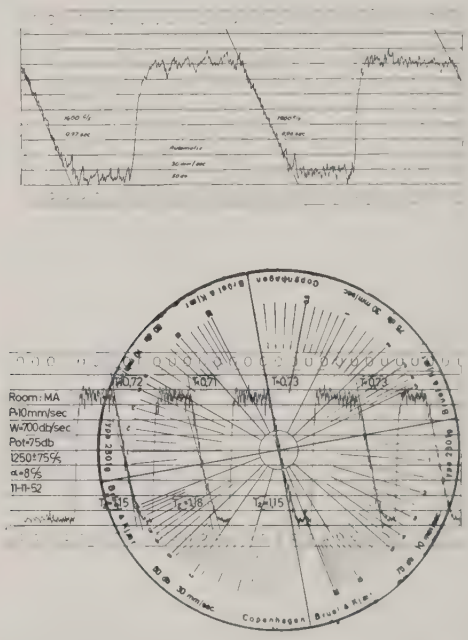



*Fig. 28. a) Reverberation measurement at 1600 c/s.*
*b) Evaluation of the reverberation time with the aid of Protractor Type 2304*

**Vibration Measurements.**

Using the Accelerometer Sets Type 4308 or 4309 and the Vibration Pick-up Preamplifier Type 1606 vibrations in buildings, machinery, ships, etc. can be measured directly in C. G. S. units. The Preamplifier 1606 can be switched for acceleration, velocity and displacement measurement.

A set-up, employing the Spectrometer and Level Recorder of the A. F. Response and Spectrum Recorder for vibration measurements on a motor's base in shown in fig. 29a.

Further information as to calibration of the set-up is given in the manual on Type 1606.

By means of the Spectrometer an analysis of the vibrations can be carried out. Fig. 29b shows a recording of the vibrations measured on an asynchronous motor fed from a 50 c/s mains supply. For the recording a 50 db potentiometer was used, the 0 db reference being equal to an acceleration of 25 cm/sec².

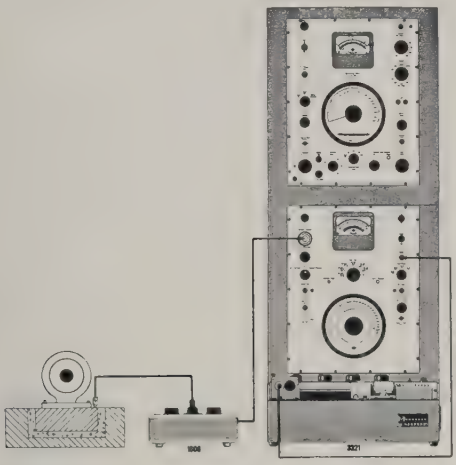


*Fig. 29a. Measuring arrangement for vibration measurements on a motor's base.*

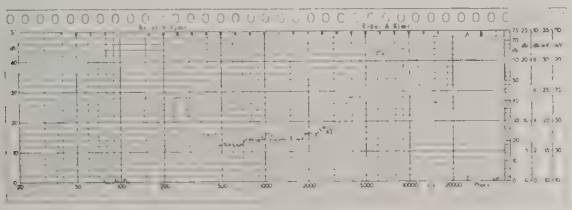


*Fig. 29b. Recording obtained with a measuring set-up as shown in fig. 29a.*

**Recording of Directional Characteristic of Loudspeakers.**

Fig. 30 shows a typical measurement for the directional characteristics of a loudspearker. The measurement is carried out by placing the loudspeaker in a sound-damped room or in the free field. The microphone is placed in a fixed position in relation to the loudspeaker. The sound pressure will vary as the loudspeaker is rotated. If there is great difference in the level in the

loudspeaker's radiation diagram, heavy demands will naturally be made on the sound damping of the room. At high frequencies therefore, one will very often notice reflections from the walls of the roof. These are clearly seen for example on the diagram belonging to fig. 30, particularly for the high frequencies.

In the free field the use of the spectrometer Type 2109 is an advantage because the noise level will be damped approx. 20 db.

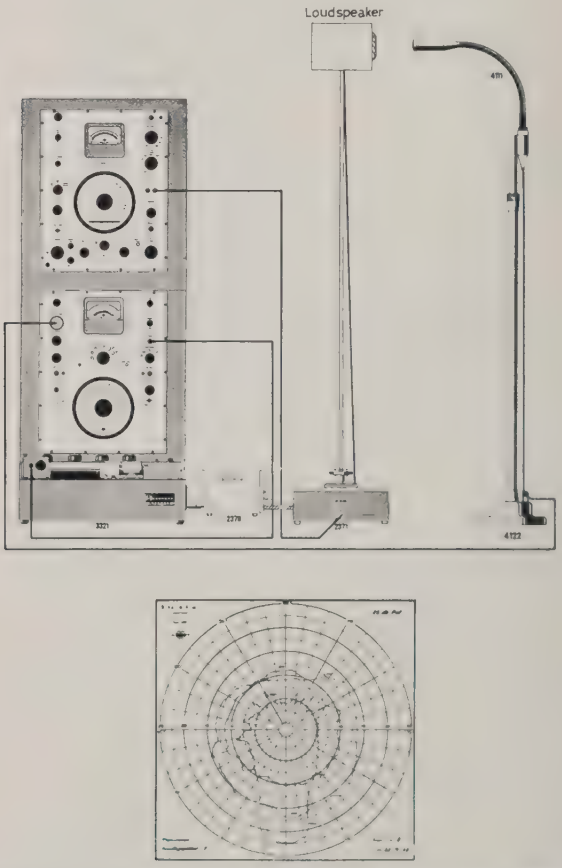



*Fig. 30. Recording of directional characteristics of loudspeakers, with example of recording.*

# Specification.

**Frequency Range:** From 20 to 200 000 c/s.

**Zero Level:** Adjustable from 5 to 14 mV. The instrument is supplied with a reference voltage of 10 mV.

**Recording System:** Patented moving-coil system.

**Recording Speed:** Variable in 9 steps from 1000 to 50 decibels per second with the 50 db potentiometer.

**Damping of the Recording System:** Feed back system giving max. restoring force.

**Potentiometers:**

| The following Potentiometers are available: | | **Accuracy** |
|---|---|---|
| Type 2341 | 35 to 110 phons Noise Level Potentiometer .. | ± 1 phon |
| » 2343 | 10 to 35 mV. Linear Potentiometer ..... | 2 % of full scale |
| » 2344 | 10 to 110 mV. Linear Potentiometer ..... | 2 % of full scale |
| » 2345 | 10 db Logarithmic Potentiometer ..... | ± 0.2 db |
| » 2346 | 25 db Logarithmic Potentiometer ..... | ± 0.3 db |
| » 2347 | 50 db Logarithmic Potentiometer (standard equipment) ..... | ± 0.5 db |
| » 2348 | 75 db Logarithmic Potentiometer ..... | ± 1 db |

The Level Recorder is delivered at catalog-price with a potentiometer Type 2343—2348.

**Paper:** 65 millimeters perforated and lined waxed paper for scratching with sapphire stylus or usual recording paper for ink writing. Effective recording width 50 millimeters. A sapphire stylus and an ink pen are supplied. The paper is illuminiated when the Level Recorder is in use.

**Paper Speed:** 10 different speeds, 100—30—10—3—1—0.3—0.1—0.03—0.01—0.003 millimeters per second.

**Drawing of Coordinate Lines:** A Scratcher Type 2360 provided with 11 sapphires for drawing 11 lines with intermediate spacing of 5 millimeters on unlined wax coated recording paper is obtainable.

**Connection to other Instruments:** Two rotating spindles can be given the following revolutions per minute: 75—22.5—7.5—2.25—0.75—0.225—0.075—0.0225 and 0.0075. The spindles rotate in opposite direction with respect to each other. To the rotating spindles may furthermore be connected the Two Channel Selector Type 4405.

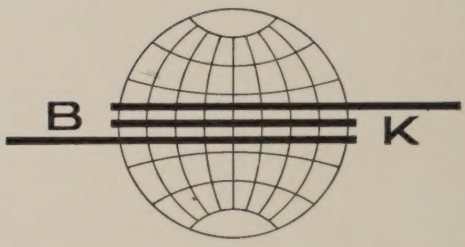
**Tubes:** 4 × 6AU6 (EF94), 2 × 6AL5 (EB91), 2 × 6AQ5 (EL90), OA2 (150C2), 6X4 (EZ90).

**European Model:** Power supply: 220 volts a. c. 50 c/s. 70 watts.

**American Model:** Power supply: 115 volts a. c. 60 c/s. 70 watts.

**Cabinet:** Mahogany cabinet with handles and lid.

| DIMENSIONS excl. dials and knobs | HEIGHT | WIDTH | DEPTH |
|---|---|---|---|
| Centimetres | 23 | 51 | 23 |
| Inches | 9 | 20 | 12 |
| WEIGHT | 28 kg | | 62 lbs. |


B
K